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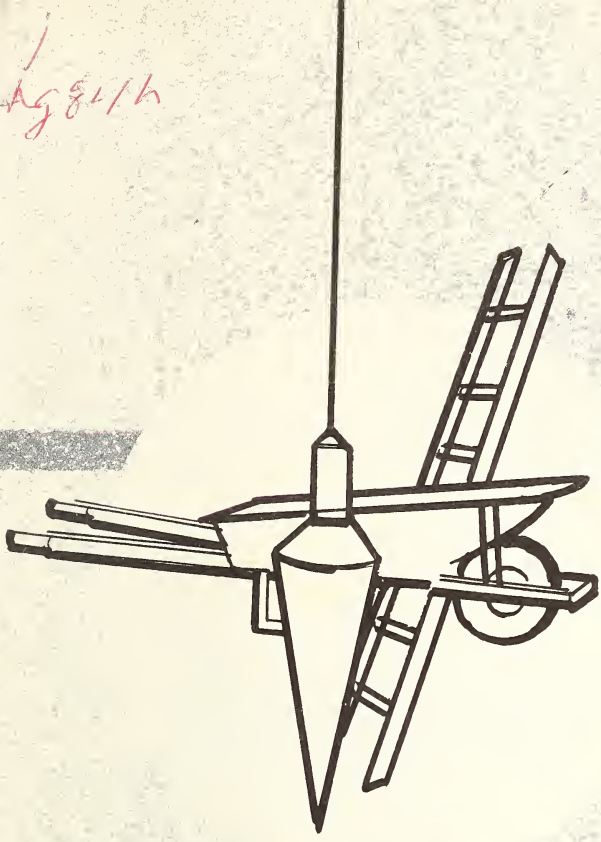

BUILDING WITH ADOBE AND STABILIZED-EARTH BLOCKS

LEAFLET NO. 535 U.S. DEPARTMENT OF AGRICULTURE

BUILDING WITH ADOBE AND STABILIZED-EARTH BLOCKS

Prepared by Agricultural Engineering Research Division,
Agricultural Research Service

Adobe and stabilized-earth blocks are inexpensive building materials for arid and semiarid climates, although they have also proven satisfactory in humid areas when protected from free water. The map in figure 1 shows the areas where they are generally used.

Figure 1.—The shaded areas are those in which earth has been used extensively in building construction.

Adobe blocks are generally made of wet clay loam and straw, but with some soils the straw is omitted. Stabilized-earth blocks are made of sandy clay loam, portland cement, and water, or of sandy clay loam, a bituminous emulsion, and water.

Earth-block buildings—that is, buildings built of either adobe blocks or stabilized-earth blocks—have these advantages:

- Most of the building material is available at no cost.
- The buildings are strong, durable, and fire resistant.
- The massive walls maintain a comfortable temperature.

The disadvantages of earth-block buildings are:

- They deteriorate with long exposure to water.
- Because the walls are massive, larger foundations are necessary.

A factor that may be an advantage or a disadvantage is the cost of labor. Unskilled labor can be employed, but a lot of man-hours are required to make and lay the blocks.

MAKING THE BLOCKS

Selecting the Soil

Select the soil for your earth blocks by the trial method. Start with a sandy clay loam, a soil that is neither high in clay content nor high in sand content. It should also be reasonably free of weeds, roots, and other organic matter.

Make a sample block from the soil you have selected, and let it dry. If it warps or cracks when it dries, there is too much clay in the soil and you will have to mix sand with it to make a satisfactory building block.

If the sample block crumbles, there is too much sand in the soil.

Don't make earth blocks during freezing or rainy weather.

Protect uncured blocks from frost—they will disintegrate if they are frozen before they are cured.

You will have to add clay, or a stabilizer, to make a satisfactory block.

The secret is to keep making sample blocks until you hit upon the mixture that is right for your soil.

Mixing the Soil

Prepare only as much soil at one time as you will need for one day's work. If the soil is cloddy, wet it the day before to soften the lumps.

You can mix the mud by hand with a hoe, or with a machine—a hoe-type plaster mixer, a pug mill, a dough mixer.

Adobe Blocks.—Pile the soil in a 3- to 4-inch layer. Puddle it into a mucky mud, and mix it thoroughly with a hoe. When it is uniformly wet, throw a layer of chopped straw on top and mix the straw into the mud. The layer of straw should be ¾ to 1 inch thick and the individual straws should be 2 to 6 inches long. If you mix the adobe in a machine, add 1 part straw to every 5 parts mud.

Be careful not to add too much straw. It will weaken the blocks.

Add water to the mud-straw mixture until the mixture is plastic enough to mold yet stiff enough to pick up with a six-tined fork. It should be stiff enough to hold the shape of a block when the form is removed.

Stabilized Blocks.—Portland cement and emulsified asphalt are the most common stabilizing additives. If you stabilize your blocks with asphalt, follow the directions of the asphalt-emulsion manufacturer. You can make blocks stabilized with portland cement as follows:

- Mix soil and cement at a ratio of 1 part cement to 12 parts soil. More cement will make a stronger block; less cement, a weaker one.
- Add water so that the mixture will form a block that can be handled, but will be at the same time as dry as possible. Too much water will reduce the strength of the cement.
- Sixty-five to 70 blocks, 4 by 6 by 12 inches each, can be made from one bag of portland cement mixed with soil at a ratio of 1 part cement to 12 parts soil. Cure all stabilized block damp for a week or two before drying.

Molding the Blocks

There are two ways to mold earth blocks—with a machine press or by casting the mud in forms by hand.

Several earth-block presses are on the market. The blocks made on them have two advantages over cast blocks. First, the press-made blocks are more uniform in size and shape; second, the press-made blocks are usually stronger—as much as twice as strong. But the presses make

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Figure 2.—Making stabilized-earth blocks with a block press.

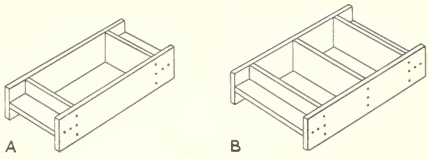

Figure 3.—Forms used for molding earth blocks: A, Single form; B, double form.

only one block at a time, and production is slower than by casting. Follow the press manufacturer's instructions; they will vary slightly with the press you buy.

Forms for molding cast blocks are shown in figure 3. Build them of lightweight, surfaced wood or of metal. Make the inside dimensions the same as the block size you want. If you line the inside of the wooden forms with metal, the mud will not stick to them.

The size of poured blocks most commonly made, and their approximate weights, are:

4 by 8 by 16 inches, 28 pounds
4 by 10 by 16 inches, 35 pounds
4 by 9 by 18 inches, 36 pounds
4 by 12 by 18 inches, 48 pounds
5 by 12 by 16 inches, 53 pounds
5 by 10 by 20 inches, 55 pounds
5 by 12 by 18 inches, 59 pounds

Select a smooth, level area of ground for a molding site. If the ground does not have a good sod, scatter straw over it, or lay down heavy butcher paper or tar paper. This prevents the blocks from sticking to the ground.

Mold the blocks in the following steps:

- Fork or shovel the prepared mud into the forms.
- Press it into the forms with a tamper or with your hands. Take care to fill the corners of the forms.
- Smooth the top of the mud with a stick or trowel.
- Lift the forms up and away and clean off the mud that sticks to them.
- Repeat the process.

Two to four men working together can mix and mold eight to ten 4- by 12- by 18-inch blocks per man-hour.

Curing the Blocks

After the blocks have dried for a few days, stand them on edge so that both sides will have fairly equal exposure to the sun and wind. Let them dry this way for a week.

When they are dry enough to handle, rub the loose dirt and straw from them. Stack them in a place where they will be protected from rain. When they have dried for 2 or 3 weeks in these stacks, they should be ready to build with.

The number of blocks required to build 100 square feet of wall depends on the size of the exposed side of the block. For instance, when 4- by 10- by 16-inch blocks are laid in ½-inch mortar joints, 305 are needed for 100 square feet of wall 16 inches thick, but only 195 blocks are needed for 100 square feet of wall 10 inches thick.

A crew of 3 men should be able to lay between 300 and 350 blocks in a wall in 8 hours.

LAYING THE BLOCKS

Building Walls

Earth block are laid in a wall in much the same manner as ordinary burnt brick. Generally, mud without straw is used for mortar and the blocks are laid in ½- to 1-inch mortar joints. Lime mortar (1 part lime and 3 parts sand) or cement mortar (1 part portland cement and 2½ parts sand) is frequently used in permanent buildings. Lime or cement mortar costs more than mud, but it sets up faster and adds to the strength of the wall.

When the blocks are made of stabilized earth, stabilized earth is often used for mortar.

About 1 cubic foot of mud or mortar is required to lay 15 to 17 blocks, 4 by 10 by 16 inches each, in ½-inch mortar joints.

The bearing walls of one-story adobe buildings and the second-story walls of two-story adobe buildings must be at least 12 inches thick. They should not be taller than 10 times their thickness. For example, a wall 12 inches thick should be no higher than 10 feet.

The lower wall of a two-story adobe building should be not less than 18 inches thick.

Stabilized-earth walls should not be taller than 12 times their thickness. And permanent buildings—such as houses—should not have walls taller than 8 times their thickness, whether built of adobe or stabilized earth, and they should not have unbuttressed walls longer than 20 times their thickness.

Do not build adobe structures higher than two stories.

Brace high or long walls until they have been permanently secured by plates and ceiling or floor joists.

Lintels are needed over door and window openings to support the wall above the opening, the roof rafters, and the second-floor joists. Make the lintels the same size and of the same material as you would for a burnt brick wall. Let them extend 9 to 12 inches beyond the jamb on each side of the opening. Set them ½ to 1 inch higher than the window or door frame to allow for wall shrinking and settling.

For a permanent earth-block building, provide a continuous concrete beam (4 to 6 inches thick and as wide as the wall) under the floor and roof plates as shown in figure 4.

An earth-block building, like any other building, needs a good foundation. The foundation should be watertight concrete and should be at least 12 inches above the outside grade and 6 to 8 inches above a concrete floor. The top of the foundation should be dampproofed to prevent moisture from rising by capillary action from the ground into the wall. For details of foundation construction and dampproofing, see Farmers' Bulletin 1869, "Foundations for Farm Buildings." For a free copy, send a post card to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250. Include your ZIP Code in your return address.

If you build your fireplace out of earth block, be sure you line it with fire-clay brick.

It is best to build the chimney out of burnt brick. Send a postal card to the U.S. Department of Agriculture, Washington, D.C. 20250, and ask for Farmers' Bulletin 1889, "Fireplaces and Chimneys."

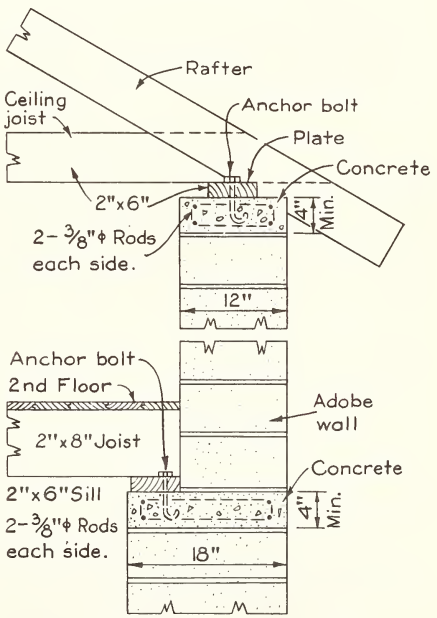

Figure 4.—Cross section of wall showing continuous concrete beams with ⅜-inch reinforcing rods.

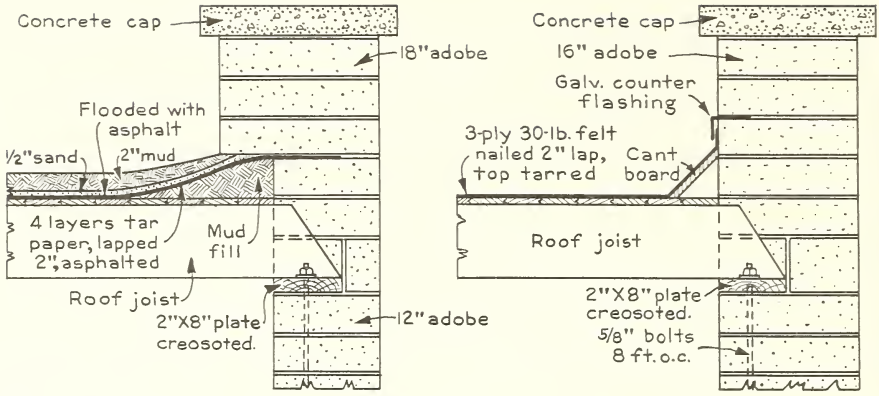

Figure 5.—Two methods of building flat roofs on earth-block buildings.

There are two ways to set door and window frames into an earth-block wall:

- Build creosoted wooden blocks into each side of the opening and nail the door or window frames to them. The creosoted blocks should be 2 by 4's at least 12 inches long; there should be three of them built into each side of the opening.
- Set bolts in the wall and bolt a rough frame in the opening. Nail the finished frame to the rough frame when the wall has dried and settled.

Reinforce these beams with two ⅜-inch steel rods on each side. The beams will distribute the floor and roof loads uniformly as well as stiffen and tie together the whole building.

Roofing Earth-Block Buildings

An earth-block building can have almost any kind of roof, so long as the roof will keep rain water away from the earth-block walls.

In arid regions, flat roofs with parapets are popular. Two methods of building flat roofs are illustrated in figure 5. Note that the top of the parapet is protected against deterioration with a concrete cap. Water is diverted from the roof-parapet joint in one case with a sloped mud fill, and in the other with a cant board and flashing.

Outlet troughs (or scuppers) are necessary to drain water from flat roofs with parapets. Build them at least 3 feet long so that they will dump the water away from the base of the wall.

You can make a good roof with felt and hot tar. Lay four or five layers of waterproof felt alternately with hot tar or asphalt. Cover the top with gravel, slag, or—in dry climates—earth.

In humid regions, the roof should be sloped and should have wide

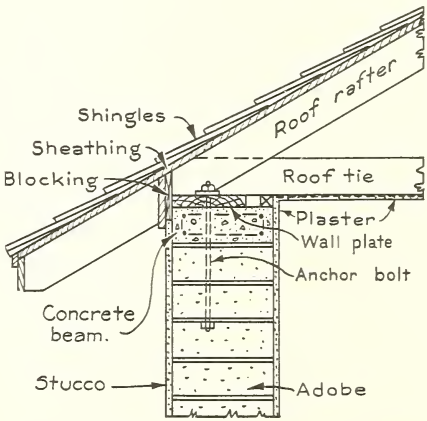

Figure 6.—Anchoring a sloped roof to an earth-block wall.

eaves. Farmers' Bulletin 2170, "Roofing Farm Buildings," describes roofs that can be adapted to earth-block buildings. Figure 6 shows how to anchor a sloped roof to an earth-block building.

Coating Outside Walls

Uncoated earth-block walls will last from 25 to 40 years in an arid climate if the top and the base are protected from moisture. An outside coating, however, will increase its lifespan. An outside coating is essential in a humid climate unless the blocks are well stabilized with cement or asphalt.

There are three types of outside-wall coatings:

- Bituminous coatings.
- Paint and whitewash coatings.
- Plaster coatings.

Bituminous Coatings.—Hot tar, cold-pitch asphalt, and Cunningham coal-tar paint are bituminous coatings.

Cunningham coal-tar paint is a mixture of 1 part portland cement, 1 part kerosene, and 4 parts coal tar by volume. The coal tar, also known as water-gas tar, can be obtained from local gas works or naval supply stores. It does not require heating or thinning with a solvent.

Mix the cement and the kerosene first, and then stir them into the tar. If the paint is too thick, thin it with kerosene.

Prime the wall with a thin coat of water-gas tar. Then apply the paint with a brush or a swab.

Ordinary paints will not cover Cunningham coal-tar paint successfully. If you want to paint over a Cunningham coal-tar coating you will have to use asphalt-base aluminum paint as a primer coat.

Paint and Whitewash Coatings.—Earth-block walls that do not have a bituminous coating can be painted. Linseed oil-lead paint is a durable and satisfactory coating.

Prime the earth blocks before you paint with a coat of linseed oil, or size them with a glue sizing. Make the sizing by mixing 1 pound of cheap glue sizing in 1 gallon of hot water.

Thin the paint for the first coat, but apply it as it comes from the can for the second.

Whitewash is cheap and easily applied, but it is neither durable nor waterproof. You can make your own whitewash as follows:

- Screen 50 pounds of hydrated lime into 6 gallons of water.
- Let it stand overnight.
- Strain out the lumps and foreign matter.
- Thin to paint consistency with clean water.

You can make a longer-lasting, but more expensive, whitewash as follows:

- Soak 5 pounds of casein in 2 gallons of hot water until the casein is thoroughly softened (about 2 hours).
- Dissolve 3 pounds of TSP (trisodium phosphate) in 1 gallon of water. Add this solution to the casein and allow the mixture to dissolve.
- When the casein-TSP mixture is thoroughly cool, stir it into 8 gallons of cool lime paste. Make the lime paste by slaking 50 pounds of hydrated lime in 6 gallons of water overnight.
- Just before using, dissolve 3 pints of formaldehyde in 3 gallons of clear water. Slowly add the formaldehyde solution to the casein-lime solution; stir constantly and vigorously. (If you add the formaldehyde too rapidly, the casein will jell and ruin the whitewash.)

Mix enough for only 1 day's painting at a time; it doesn't keep.

Plaster Coatings.—You can plaster outside walls with mud or with stucco.

Mud plaster will improve the appearance of the building with little

cost, but it must be painted to withstand the weather.

Mud plaster should be fairly stiff and fairly sandy. Mix 2 parts sand to 1 part mud. Apply it in two coats.

Lime-stucco and cement-stucco plasters are more durable than mud plaster. Cement stucco is more durable than lime stucco.

Allow the earth-block walls to dry and settle for 2 months before stuccoing them. Apply the stucco in two coats.

The first coat of stucco must be bonded to the wall. Figure 7 illustrates one method of bonding stucco with nails. Another method is to nail the first coat to the wall with tenpenny or twelvepenny nails. The nailing has to be done within 15 minutes after applying the first coat. Drive them flush with the mortar surface; space them about 12 inches apart at random (not in a straight line). A third method is to apply the stucco over metal lath.

The second coat of stucco has to be bonded to the first. The easiest way to make this bond is to scratch the first coat before it hardens. A board with nails driven through it, like a sharp rake, makes an excellent scratcher.

To make lime-stucco plaster, mix 1 part lime putty with 3 parts sand. Make the lime putty by slaking 44 pounds of hydrated lime or 27 pounds of quicklime in 6 gallons of water. Let the hydrated lime slake for at least 24 hours; let the quicklime slake for at least a week before mixing the plaster.

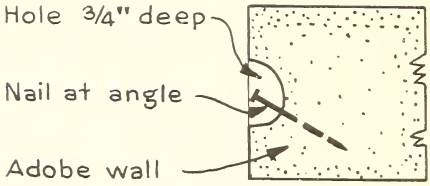

Figure 7.—**Holes about three-fourths of an inch deep are made in each block by striking the block with a sharp tool. Eightpenny or tenpenny nails are driven in at an angle until the heads are flush with the wall.**

To make cement-stucco plaster, mix 1 part portland cement with about 3 parts sand. If you add 10 pounds of hydrated lime for each bag of cement the stucco will be easier to work.

Coating Inside Walls

Inside walls can be coated with paint or plaster like outside walls. They can be plastered first with mud and then with lime plaster. They can be plastered with mud and then painted, calcimined, or papered. They can be plastered with lime mortar over metal lath.

Animals like to lick and rub against earth walls. Protect the corners with corner boards and the doorjambs with casings. Coat the interior walls that are within the reach of tied or penned animals with a bituminous coating or portland-cement plaster.

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